CHAPTER 1

LIGHT — REFLECTION AND REFRACTION

FREE SAMPLE CHAPTER — from PHYSICS BLITZ (full book ₹95 only)

Based strictly on the NCERT Class X Science textbook (Chapter 9). Structured for the CBSE 2027 competency-based examination pattern: MCQs, Assertion–Reason, 2/3/5-mark questions and case-based questions, each with a full worked answer key.

1. BOARD TREND ANALYSIS & 2027 PATTERN MAP

How this chapter behaves in the board exam. "Light — Reflection and Refraction" is one of the highest-scoring physics chapters. In recent board papers it has consistently contributed roughly 6–8 marks, spread across the MCQ/Assertion–Reason section, one short-answer numerical, and either a ray-diagram question or a case-based question. The questions are predictable: they revolve around the mirror formula, the lens formula, sign convention, power of a lens, and refraction through a glass slab.

1.1 What recent papers have asked (observed pattern)

Concept area	How often it appears	Usual format & marks
Mirror formula / lens formula numericals	Almost every year	2 or 3 marks; sometimes inside a 5-mark question
Ray diagrams (image formation by mirrors & lenses)	Almost every year	2–3 marks; often clubbed with a numerical
Refraction through a rectangular glass slab	Very frequent	2–3 marks (diagram + 'emergent ray parallel' reasoning)
Refractive index & speed of light	Very frequent	1–2 marks; classic 'n = 1.5, find speed' type
Power of a lens / combination of lenses	Very frequent	1–2 marks; MCQ or VSA
Uses of mirrors (headlight, rear-view, solar furnace)	Frequent	1-mark MCQ / Assertion–Reason / case-based
Sign convention 'trap' questions	Frequent	1-mark MCQ (sign of f, meaning of m = +1, –1)

1.2 CBSE 2027 paper structure — where this chapter fits

Paper section	Question type	Expected from this chapter
Section A	MCQ + Assertion–Reason (1 mark each)	2–3 questions (sign convention, power, uses of mirrors, refraction facts)
Section B	Very Short Answer (2 marks)	1 question (definition + small numerical, e.g. dioptre, refractive index)
Section C	Short Answer (3 marks)	1 question (numerical with sign convention OR glass-slab diagram)
Section D	Long Answer (5 marks)	Possible: full image-formation question (table + ray diagram + numerical)
Section E	Case/Source-based (4 marks)	Possible: rear-view mirror / optician-prescription passage

Examiner's focus for 2027: about half the paper is competency-based. Expect application settings (driving mirrors, spectacles, magnifying glass, coin-in-water) rather than plain definitions. Every numerical answer must show the sign convention explicitly — marks are awarded for correct substitution with signs, not just the final value.

2. RAPID REVISION — THE COMPLETE CORE IN ONE PLACE

2.1 Formula sheet

Relation	Formula	Remember
Focal length – radius of curvature	$f = R/2$	Valid for both spherical mirrors
Mirror formula	$1/v + 1/u = 1/f$	Valid for all spherical mirrors, all positions
Magnification (mirror)	$m = h'/h = -v/u$	m negative → real & inverted; m positive → virtual & erect
Snell's law	$\sin i / \sin r = \text{constant } (n_{21})$	For a given colour and pair of media
Refractive index (relative)	$n_{21} = v_1/v_2$	Speed in medium 1 ÷ speed in medium 2
Refractive index (absolute)	$n = c/v$	$c = 3 \times 10^8$ m s^{-1} (speed in vacuum)
Lens formula	$1/v - 1/u = 1/f$	Note the minus sign — different from mirrors!
Magnification (lens)	$m = h'/h = v/u$	No minus sign here — different from mirrors!
Power of a lens	$P = 1/f$ (f in metres)	Unit: dioptre (D); 1 D = 1 m^{-1}
Combination of thin lenses	$P = P_1 + P_2 + P_3 + \ldots$	Simple algebraic addition (with signs)

2.2 Sign convention — the five rules that decide your marks

1. All distances are measured from the pole of the mirror (or optical centre of the lens).
2. Distances measured in the direction of incident light are positive; against it, negative. So the object distance u is always negative.
3. Heights above the principal axis are positive; below it, negative.
4. Focal length: concave mirror and concave lens → negative; convex mirror and convex lens → positive.
5. Magnification: positive m means virtual and erect; negative m means real and inverted.

2.3 Image positions at a glance

Concave mirror

Object position	Image position	Nature & size
At infinity	At focus F	Real, inverted, point-sized
Beyond C	Between F and C	Real, inverted, diminished
At C	At C	Real, inverted, same size
Between C and F	Beyond C	Real, inverted, enlarged
At F	At infinity	Real, inverted, highly enlarged
Between P and F	Behind the mirror	Virtual, erect, enlarged

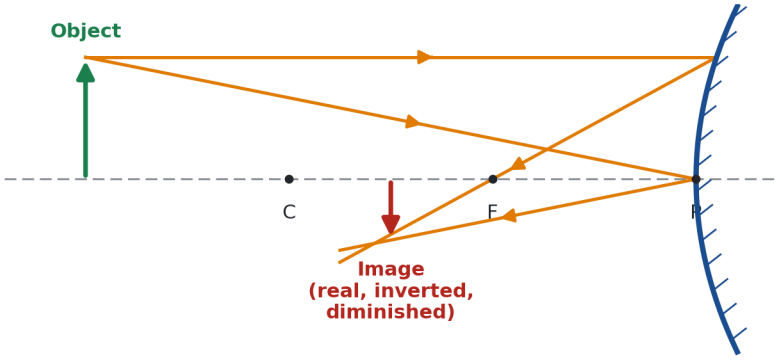

Fig. 1 Concave mirror — object beyond C gives a real, inverted, diminished image between F and C.

Convex lens

Object position	Image position	Nature & size
At infinity	At focus F_2	Real, inverted, point-sized
Beyond $2F_1$	Between F_2 and $2F_2$	Real, inverted, diminished
At $2F_1$	At $2F_2$	Real, inverted, same size
Between F_1 and $2F_1$	Beyond $2F_2$	Real, inverted, enlarged
At F_1	At infinity	Real, inverted, highly enlarged
Between F_1 and O	Same side as object	Virtual, erect, enlarged (magnifying glass!)

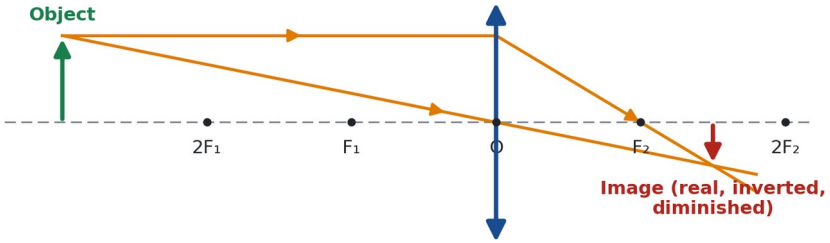

Fig. 2 Convex lens — object beyond $2F_1$ gives a real, inverted, diminished image between F_2 and $2F_2$.

Fixed-image devices: a convex mirror and a concave lens always form a virtual, erect, diminished image, whatever the object position. A plane mirror always forms a virtual, erect, same-size image.

2.4 Refraction essentials

When light passes obliquely from one transparent medium to another, its speed changes, so its direction changes. Going from a rarer to a denser medium (air → glass) it slows down and bends towards the normal; going from denser to rarer (glass → air) it speeds up and bends away from the normal. A medium with a higher refractive index is optically denser — note that kerosene (n = 1.44) is optically denser than water (n = 1.33) even though its mass density is lower.

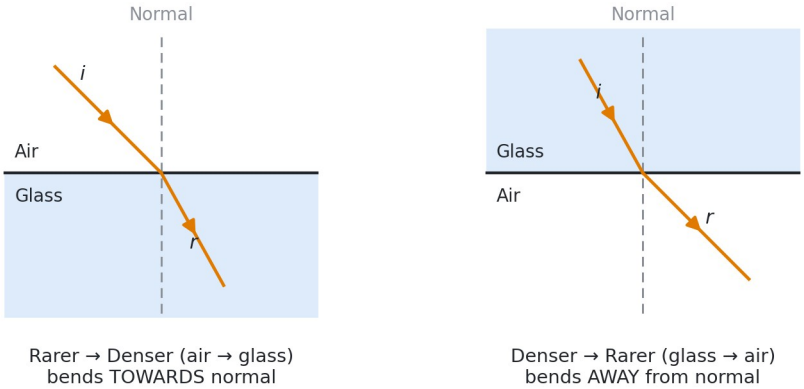

Fig. 3 Bending of light at a boundary: towards the normal (rarer → denser) and away from the normal (denser → rarer).

SECTION A — MULTIPLE CHOICE QUESTIONS (1 MARK EACH)

Q1. Which of the following materials cannot be used to make a lens? *[1 mark]*

(a) Water (b) Glass
(c) Plastic (d) Clay

Q2. The image formed by a concave mirror is virtual, erect and larger than the object. The object must be placed: *[1 mark]*

(a) between F and C (b) at C
(c) beyond C (d) between the pole P and focus F

Q3. To obtain a real image of the same size as the object using a convex lens, the object should be placed: *[1 mark]*

(a) at the focus F_1 (b) at $2F_1$
(c) at infinity (d) between O and F_1

Q4. A spherical mirror and a thin spherical lens each have a focal length of −15 cm. They are most likely: *[1 mark]*

(a) both concave (b) both convex
(c) a concave mirror and a convex lens (d) a convex mirror and a concave lens

Q5. No matter how far you stand from a certain mirror, your image is always erect. The mirror could be: *[1 mark]*

(a) only plane (b) only concave
(c) only convex (d) either plane or convex

Q6. For reading the tiny letters of a dictionary you should prefer: *[1 mark]*

(a) a convex lens of focal length 50 cm (b) a concave lens of focal length 50 cm
(c) a convex lens of focal length 5 cm (d) a concave lens of focal length 5 cm

Q7. Light travels slowest in the medium whose refractive index is: *[1 mark]*

(a) 1.33 (water) (b) 1.50 (benzene)
(c) 1.65 (flint glass) (d) 2.42 (diamond)

Q8. A ray of light strikes the surface of a mirror along its normal. The angle of reflection is: *[1 mark]*

(a) 0° (b) 45°
(c) 90° (d) equal to the critical angle

Q9. The refractive index of glass is 1.5. The speed of light in glass is: *[1 mark]*

(a) 3×10^8 m s^{-1} (b) 2×10^8 m s^{-1}
(c) 1.5×10^8 m s^{-1} (d) 4.5×10^8 m s^{-1}

Q10. A lens has a power of −2.5 D. Its nature and focal length are: *[1 mark]*

(a) convex, +40 cm (b) concave, −40 cm
(c) convex, +25 cm (d) concave, −25 cm

Q11. The magnification produced by a plane mirror is +1. This means the image is: *[1 mark]*

(a) real, inverted, same size (b) virtual, erect, same size
(c) virtual, erect, enlarged (d) real, erect, same size

Q12. A ray of light passes through a rectangular glass slab. The emergent ray is: *[1 mark]*

(a) bent towards the normal (b) bent away from the normal
(c) parallel to the incident ray but laterally shifted (d) along the same straight line as the incident ray

Q13. A ray of light travels from water (n = 1.33) into kerosene (n = 1.44). The ray will: *[1 mark]*

(a) bend towards the normal (b) bend away from the normal
(c) go undeviated (d) be reflected back completely

Q14. A concave mirror produces a magnification of −1. The object is placed: *[1 mark]*

(a) at the focus F (b) at the centre of curvature C

(c) between P and F (d) beyond C

Q15. Two thin lenses of powers +2 D and −4 D are placed in contact. The combination behaves as: *[1 mark]*

(a) a converging lens of power +2 D (b) a diverging lens of power −2 D

(c) a converging lens of power +6 D (d) a diverging lens of power −6 D

Answers — Section A (with one-line reasons)

A1. **(d) Clay.** A lens must be transparent; clay is opaque.

A2. **(d) Between P and F.** This is the only position where a concave mirror gives a virtual, erect, enlarged image.

A3. **(b) At $2F_1$.** Object at $2F_1$ → image at $2F_2$, real, inverted, same size.

A4. **(a) Both concave.** Negative focal length means concave for both mirrors and lenses (New Cartesian convention).

A5. **(d) Either plane or convex.** Both always give a virtual, erect image for every object position.

A6. **(c) Convex lens, f = 5 cm.** A short-focal-length convex lens gives greater magnification when used as a magnifier.

A7. **(d) Diamond (n = 2.42).** n = c/v, so the largest n means the smallest speed v.

A8. **(a) 0°.** Along the normal, angle of incidence = 0°, so angle of reflection = 0°; the ray retraces its path.

A9. **(b) 2×10^8 m s^{-1}.** $v = c/n = (3 \times 10^8)/1.5 = 2 \times 10^8$ m s^{-1}.

A10. **(b) Concave, −40 cm.** f = 1/P = 1/(−2.5) = −0.40 m = −40 cm; negative power ⇒ concave (diverging).

A11. **(b) Virtual, erect, same size.** m = +1 means h′ = h (same size) and the + sign means virtual and erect.

A12. **(c) Parallel but laterally shifted.** Equal and opposite bending at the two parallel faces makes the emergent ray parallel, with a sideways shift.

A13. **(a) Towards the normal.** Kerosene has the higher refractive index, so it is optically denser; light bends towards the normal.

A14. **(b) At C.** m = −1 ⇒ real, inverted, same size — which happens only when the object is at C.

A15. **(b) Diverging lens of power −2 D.** $P = P_1 + P_2 = +2 + (-4) = -2$ D; negative ⇒ diverging.

SECTION B — ASSERTION–REASON QUESTIONS (1 MARK EACH)

For each question choose:

(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.

Q1. **Assertion (A):** Convex mirrors are used as rear-view mirrors in vehicles.
Reason (R): A convex mirror always gives an erect, diminished image and covers a much wider field of view than a plane mirror of the same size.

Q2. **Assertion (A):** A concave mirror always forms a real image.
Reason (R): A real image is formed when reflected rays actually meet at a point.

Q3. **Assertion (A):** A ray of light entering glass from air bends towards the normal.
Reason (R): The speed of light decreases when light enters an optically denser medium.

Q4. **Assertion (A):** The power of a concave lens is always negative.
Reason (R): By the sign convention, the focal length of a concave lens is negative, and P = 1/f.

Q5. **Assertion (A):** A ray passing through the optical centre of a lens goes through without any deviation.
Reason (R): Near the optical centre, the two surfaces of the lens are effectively parallel to each other.

Q6. **Assertion (A):** Kerosene is optically denser than water.
Reason (R): Optical density is decided by mass density.

Answers — Section B

A1. **(a)** Both statements are true and the wide field of view with erect images is exactly why convex mirrors are chosen.

A2. **(d)** A is false — when the object lies between P and F, a concave mirror forms a virtual image. R is a true statement.

A3. **(a)** The slowing down of light in the denser medium is the cause of the bending towards the normal.

A4. **(a)** Negative f directly gives negative power; R correctly explains A.

A5. **(a)** The thin central region acts like a very thin parallel-sided slab, so the ray emerges undeviated.

A6. **(c)** A is true (n of kerosene 1.44 > n of water 1.33). R is false — optical density depends on refractive index, not mass density.

SECTION C — VERY SHORT ANSWER QUESTIONS (2 MARKS EACH)

Q1. Define the principal focus of a concave mirror. How is the focal length of a spherical mirror related to its radius of curvature? *[2 marks]*

Ans. The principal focus of a concave mirror is the point on the principal axis at which rays coming parallel to the principal axis actually meet after reflection.

Relation: f = R/2, i.e. the focal length is half the radius of curvature.

Q2. Find the focal length of a convex mirror whose radius of curvature is 32 cm. *[2 marks]*

Ans. f = R/2 = 32/2 = 16 cm.

Since the mirror is convex, f = +16 cm (positive by the sign convention).

Q3. Why is a concave mirror used in torches and car headlights? Where is the bulb placed? *[2 marks]*

Ans. The bulb is placed at the principal focus of the concave mirror.

Rays starting from the focus become parallel to the principal axis after reflection, producing a strong parallel beam that travels a long distance.

Q4. The refractive index of diamond is 2.42. What is the meaning of this statement? *[2 marks]*

Ans. It means light travels 2.42 times faster in vacuum (or air) than in diamond.

In other words, speed of light in diamond = $c/2.42 = (3 \times 10^8)/2.42 \approx 1.24 \times 10^8$ m s^{-1}.

Q5. A ray of light travelling in air enters obliquely into water. Does it bend towards or away from the normal? Give the reason. *[2 marks]*

Ans. It bends towards the normal.

Water is optically denser than air, so light slows down on entering water; a slowing ray bends towards the normal.

Q6. Light enters from air into glass of refractive index 1.50. Calculate the speed of light in the glass. (Speed of light in vacuum = 3×10^8 m s^{-1}) *[2 marks]*

Ans. $n = c/v \Rightarrow v = c/n = (3 \times 10^8)/1.50$

$v = 2 \times 10^8$ m s^{-1}.

Q7. The magnification produced by a plane mirror is +1. What does this mean? *[2 marks]*

Ans. The magnitude 1 means the image is exactly the same size as the object (h′ = h).

The plus sign means the image is virtual and erect.

Q8. One half of a convex lens is covered with black paper. Will the lens still produce a complete image of an object? Explain. *[2 marks]*

Ans. Yes, a complete image is still formed, because rays from every point of the object pass through the uncovered half of the lens and are refracted to form the full image.

However, fewer rays now form the image, so the image is less bright (dimmer).

Q9. Define 1 dioptre of power. Find the power of a concave lens of focal length 2 m. *[2 marks]*

Ans. 1 dioptre is the power of a lens whose focal length is 1 metre (1 D = 1 m^{-1}).

P = 1/f = 1/(−2 m) = −0.5 D.

Q10. A pencil partly immersed in a glass of water appears bent at the water surface. Name and explain the phenomenon responsible. *[2 marks]*

Ans. The phenomenon is refraction of light.

Light coming from the part of the pencil inside water bends away from the normal as it passes from water (denser) to air (rarer), so this part appears displaced from its true position, making the pencil look bent at the interface.

SECTION D — SHORT ANSWER QUESTIONS (3 MARKS EACH)

Q1. State the laws of refraction of light. Which of these is known as Snell's law? *[3 marks]*

Ans. Law 1: The incident ray, the refracted ray and the normal to the interface of the two transparent media at the point of incidence all lie in the same plane.

Law 2: For a given colour of light and a given pair of media, the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant: $\sin i / \sin r = \text{constant}$.

The second law is called Snell's law of refraction. The constant is the refractive index of the second medium with respect to the first (n_{21}).

Q2. A ray of light passes through a rectangular glass slab. Draw a labelled diagram of its path and explain why the emergent ray is parallel to the incident ray. What is lateral displacement? *[3 marks]*

Ans. At the air–glass face the ray bends towards the normal (entering a denser medium); at the glass–air face it bends away from the normal (entering a rarer medium).

The bending at the two faces is equal in amount and opposite in direction because the two faces are parallel. Hence the emergent ray comes out parallel to the incident ray.

The perpendicular (sideways) shift between the incident ray produced forward and the emergent ray is called the lateral displacement of the ray.

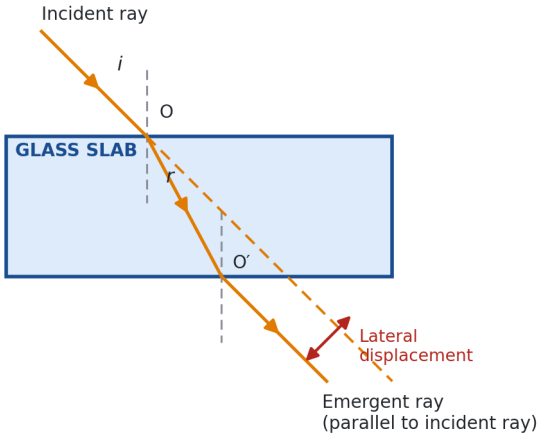

Fig. 4 Refraction through a rectangular glass slab — the emergent ray is parallel to the incident ray but laterally displaced.

Q3. We wish to obtain an erect image of an object using a concave mirror of focal length 15 cm. What should be the range of the object distance? State the nature and relative size of the image, and draw the ray diagram. *[3 marks]*

Ans. A concave mirror gives an erect image only when the object lies between the pole P and the principal focus F.

So the object must be placed at a distance less than 15 cm from the mirror (0 < object distance < 15 cm).

The image formed is virtual, erect and larger than the object, and it appears behind the mirror. (This is how a shaving/make-up mirror and a dentist's mirror work.)

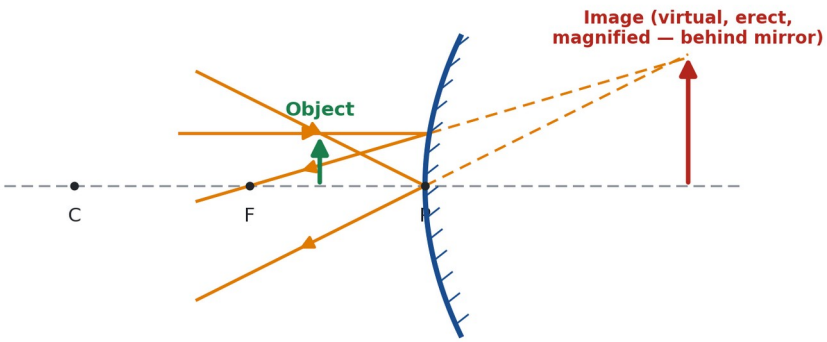

Fig. 5 Object between P and F of a concave mirror — virtual, erect, magnified image behind the mirror.

Q4. A concave mirror produces a three-times magnified real image of an object placed 10 cm in front of it. Where is the image located? *[3 marks]*

Ans. Given: u = −10 cm. The image is real, so the magnification is negative: m = −3.

m = −v/u ⇒ −3 = −v/(−10) ⇒ −3 = v/10 ⇒ v = −30 cm.

The image is formed 30 cm in front of the mirror (on the same side as the object), real and inverted.

Q5. An object 5.0 cm tall is placed 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position, nature and size of the image. *[3 marks]*

Ans. Given: h = +5.0 cm, u = −20 cm, R = +30 cm ⇒ f = R/2 = +15 cm.

Mirror formula: 1/v + 1/u = 1/f ⇒ 1/v = 1/f − 1/u = 1/15 − (−1/20) = 1/15 + 1/20 = (4 + 3)/60 = 7/60.

⇒ v = 60/7 ≈ +8.6 cm. The + sign shows the image is behind the mirror → virtual and erect.

m = −v/u = −(60/7)/(−20) = +3/7; h′ = m × h = (3/7)(5.0) ≈ +2.1 cm.

Image: 8.6 cm behind the mirror, virtual, erect, diminished (about 2.1 cm tall).

Q6. A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram for image formation by a concave lens. *[3 marks]*

Ans. Given: f = −15 cm. A concave lens forms its image on the same side as the object, so v = −10 cm.

Lens formula: 1/v − 1/u = 1/f ⇒ 1/u = 1/v − 1/f = (−1/10) − (−1/15) = −1/10 + 1/15 = (−3 + 2)/30 = −1/30.

⇒ u = −30 cm. The object is placed 30 cm in front of the concave lens.

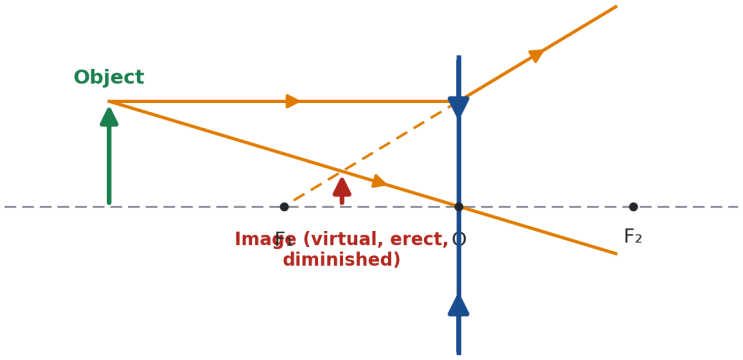

Fig. 6 Image formation by a concave lens — always virtual, erect and diminished, on the object's side.

Q7. A convex lens forms a real and inverted image of a needle at a distance of 50 cm from the lens, and the image is the same size as the needle. Where is the needle placed? Also find the power of the lens. *[3 marks]*

Ans. Image is real and of the same size ⇒ the object is at $2F_1$ and the image at $2F_2$. So v = +50 cm and u = −50 cm.

Then 2f = 50 cm ⇒ f = +25 cm = +0.25 m. (Check with the lens formula: 1/f = 1/v − 1/u = 1/50 + 1/50 = 2/50 ⇒ f = 25 cm.)

Power P = 1/f = 1/0.25 = +4 D.

Q8. Name the type of mirror used in each case and justify your choice: (a) headlight of a car, (b) side/rear-view mirror of a vehicle, (c) solar furnace. *[3 marks]*

Ans. (a) Concave mirror — with the bulb at its focus, the reflected rays form a powerful parallel beam.

(b) Convex mirror — it always gives an erect, diminished image and provides a much wider field of view, letting the driver see a large area of traffic behind.

(c) Concave mirror (large) — it converges sunlight to a point at its focus, concentrating heat on the object placed there.

SECTION E — LONG ANSWER QUESTIONS (5 MARKS EACH)

Q1. An object 7.0 cm tall is placed 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed to obtain a sharp image? Find the size and nature of the image. *[5 marks]*

Ans. Given: h = +7.0 cm, u = −27 cm, f = −18 cm (concave mirror).

Mirror formula: $1/v = 1/f - 1/u = (-1/18) - (-1/27) = -1/18 + 1/27 = (-3 + 2)/54 = -1/54$.

$\Rightarrow$ v = −54 cm. The screen must be placed 54 cm in front of the mirror (same side as the object).

$m = -v/u = -(-54)/(-27) = -2$; $h' = m \times h = (-2)(7.0) = -14$ cm.

Nature: the negative v and negative h′ show the image is real, inverted, and enlarged — 14 cm tall, formed 54 cm from the mirror.

Q2. An object 5 cm in length is held 25 cm away from a converging lens of focal length 10 cm. Find the position, size and nature of the image. Support your answer with a ray diagram. *[5 marks]*

Ans. Given: h = +5 cm, u = −25 cm, f = +10 cm.

Lens formula: $1/v = 1/f + 1/u = 1/10 + (-1/25) = (5 - 2)/50 = 3/50 \Rightarrow v = 50/3 \approx +16.7$ cm.

The + sign shows the image forms on the other side of the lens → real image.

$m = v/u = (50/3)/(-25) = -2/3$; $h' = m \times h = (-2/3)(5) \approx -3.3$ cm.

The image is real, inverted and diminished (≈3.3 cm), formed about 16.7 cm behind the lens — exactly as the ray diagram for an object beyond $2F_1$ predicts (see Fig. 2 in the Rapid Revision section).

Q3. (a) Define refractive index of a medium in terms of the speed of light. (b) The speed of light in vacuum is 3×10^8 m s^{-1} and in water it is 2.25×10^8 m s^{-1}. Calculate the refractive index of water. (c) Out of kerosene (n = 1.44), turpentine (n = 1.47) and water (n = 1.33), in which does light travel fastest, and why? *[5 marks]*

Ans. (a) The absolute refractive index of a medium is the ratio of the speed of light in vacuum to the speed of light in that medium: n = c/v.

(b) $n(\text{water}) = c/v = (3 \times 10^8)/(2.25 \times 10^8) = 1.33$.

(c) Light travels fastest in water. Since v = c/n, the speed is highest in the medium with the lowest refractive index, and water has the smallest n (1.33) of the three.

Extra insight (competency): a higher refractive index means the medium is optically denser — this need not match mass density (kerosene floats on water yet is optically denser).

Q4. (a) Why does a convex mirror never form a real image, whatever the position of the object? (b) An object is placed 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image. (c) State one practical use of a convex mirror linked to this property. *[5 marks]*

Ans. (a) In a convex mirror the reflected rays always diverge; they never actually meet. Only their backward extensions appear to meet behind the mirror, so the image is always virtual (and erect and diminished).

(b) Given: u = −10 cm, f = +15 cm. $1/v = 1/f - 1/u = 1/15 - (-1/10) = 1/15 + 1/10 = (2 + 3)/30 = 5/30 = 1/6$.

$\Rightarrow$ v = +6 cm. The image forms 6 cm behind the mirror; $m = -v/u = -6/(-10) = +0.6$.

Nature: virtual, erect and diminished (0.6 times the object's size).

(c) Rear-view/side mirrors of vehicles — the always-erect, diminished images give the driver a wide, upright view of the traffic behind.

Q5. (a) Define power of a lens and its SI unit. (b) A doctor prescribes a corrective lens of power +1.5 D. Find its focal length and state whether it is converging or diverging. (c) During an eye test, the optician combines lenses of powers +2.0 D and +0.25 D in contact. What single lens is this equivalent to? (d) Find the focal length of a lens of power −2.0 D and name its type. *[5 marks]*

Ans. (a) The power of a lens is the degree of convergence or divergence of light it produces, defined as the reciprocal of its focal length: P = 1/f (f in metres). SI unit: dioptre (D); 1 D = 1 m^{-1}.

(b) f = 1/P = 1/1.5 ≈ +0.67 m. The positive sign means a convex (converging) lens.

(c) Net power P = P_1 + P_2 = 2.0 + 0.25 = +2.25 D — equivalent to a single convex lens of focal length 1/2.25 ≈ 0.44 m.

(d) f = 1/(−2.0) = −0.5 m = −50 cm. The negative sign means a concave (diverging) lens.

SECTION F — CASE / COMPETENCY-BASED QUESTIONS (4 MARKS EACH)

Case 1 — The driver's extra pair of eyes

Riya notices that the side mirror of her school van carries the warning: “Objects in the mirror are closer than they appear.” Her teacher explains that this mirror always shows an upright picture of the road behind, and that vehicles in it look smaller than they really are — which is exactly why the mirror lets the driver watch a very wide stretch of road in one glance.

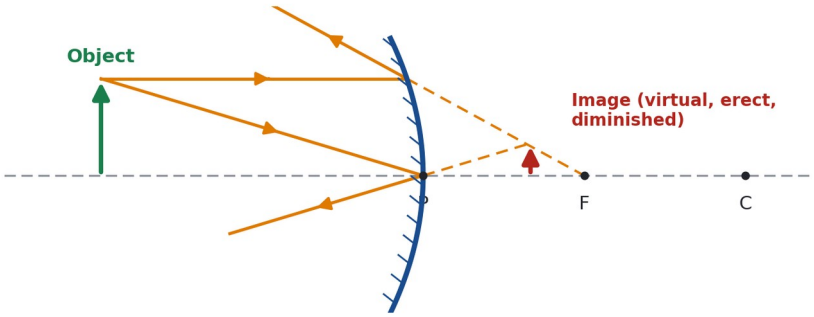

Fig. 7 A convex mirror always forms a virtual, erect, diminished image behind the mirror.

Q1. (i) Which type of mirror is fitted on the van, and what is the sign of its focal length? *[1 mark]*

Ans. A convex mirror; its focal length is positive by the New Cartesian sign convention.

Q2. (ii) State the nature of the image this mirror forms for any position of the object. *[1 mark]*

Ans. Always virtual, erect and diminished, formed behind the mirror.

Q3. (iii) Why do vehicles “appear closer than they are” misjudged in this mirror? *[1 mark]*

Ans. Because the image is diminished, the brain interprets the small image as a distant object; the actual vehicle is closer than the small image suggests — hence the warning.

Q4. (iv) A car is 3.0 m from the mirror (f = +1.0 m). Find the image distance. *[1 mark]*

Ans. u = −3.0 m, f = +1.0 m. $1/v = 1/f - 1/u = 1 + 1/3 = 4/3 \Rightarrow v = +0.75$ m, i.e. 0.75 m behind the mirror (virtual, erect).

Case 2 — At the optician's table

During an eye check-up, the optician slides thin lenses of known powers into a testing frame, one in front of the other, and simply adds their powers to find the final prescription. For Arjun he arrives at a lens of power −2.5 D; for his grandmother the prescription reads +1.5 D. The optician mentions that using powers instead of focal lengths makes this addition effortless.

Q1. (i) What is the nature (type) of Arjun's prescribed lens and of his grandmother's lens? *[1 mark]*

Ans. Arjun: power negative ⇒ concave (diverging) lens. Grandmother: power positive ⇒ convex (converging) lens.

Q2. (ii) Calculate the focal length of Arjun's lens. *[1 mark]*

Ans. f = 1/P = 1/(−2.5) = −0.40 m = −40 cm.

Q3. (iii) Two testing lenses of powers +2.0 D and −0.5 D are placed in contact. Find the power and focal length of the combination. *[1 mark]*

Ans. P = +2.0 − 0.5 = +1.5 D; f = 1/1.5 ≈ +0.67 m (converging combination).

Q4. (iv) Why is it more convenient for opticians to work with powers rather than focal lengths? *[1 mark]*

Ans. Because for lenses in contact the powers simply add algebraically ($P = P_1 + P_2 + \ldots$), whereas focal lengths would need reciprocal calculations at every step.

QUICK SELF-CHECK BEFORE THE EXAM

✓ Can I write the mirror formula AND the lens formula without mixing up the signs? (1/v + 1/u vs 1/v − 1/u)

✓ Do I always substitute u as negative?

✓ Can I state, without looking, which two devices always give virtual–erect–diminished images? (Convex mirror, concave lens)

✓ Can I draw the glass-slab diagram with normals, i, r and the lateral displacement marked?

✓ Can I convert power ↔ focal length in one step, including the sign?

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